

0.5
D

U. S. Department of Agriculture - Forest Service
CENTRAL STATES FOREST EXPERIMENT STATION
Columbus, Ohio

RECEIVED
NORTHEASTERN FOREST
EXPERIMENT STATION
NOV 30 1934

Station Note
No. 16

November 20, 1934.

THE EFFECT OF FOREST BURNING AND PASTURING IN THE OZARKS
ON THE WATER ABSORPTION OF FOREST SOILS

John T. Auten, Silviculturist

The importance of forests in building and retaining soil porosity and water-absorbing capacity can scarcely be overestimated. In many regions, failure of springs and streams, lowering of ground water levels, and serious increase in soil erosion are caused by removing forests from non-agricultural land, or by destroying the effectiveness of forest cover through repeated burning or excessive grazing. Both droughts and floods of recent years have emphasized the necessity of reducing surface water run-off and of improving those conditions of soil and vegetative cover which help to absorb and conserve rainfall.

In a previous report (1) of this Station, soil porosity and rates of water absorption in old-growth woods, second-growth woods, and forest plantations were compared respectively with those of adjacent field soils. It was shown clearly that soil under old-growth forest is much more porous and has a far greater water-holding capacity than the same soil cleared and cultivated or seeded to grass. This was also found to be true of second-growth woods where grazing of livestock had not been permitted. In the case of forest plantations on compacted old-field soil, soil porosity had increased and water absorption capacity had been restored to a great extent during the twenty-five to thirty years during which the plantations had been established.

This former study was conducted chiefly on the glaciated silt-loam and clay soils of the Corn Belt. The few tests of coarser textured sandy soils indicated the retention of more porosity after clearing and cultivation than was found in the finer silts and clays, but the need for more data on sandy soils was apparent. The question also arose as to the porosity of the stony or cherty soils typical of large portions of the extensive Ozark forest region. Of special importance was the determination of the effects of repeated forest burning and excessive grazing, so prevalent in the Ozarks, on the water absorptive capacity of the cherty soils of Missouri and Arkansas, and of the loessial soils of southern Illinois.

(1) Porosity and Water Absorption of Forest Soils, by John T. Auten.
Jour. of Agri. Research, Vol. 46, No. 11, pp. 997-1014. June, 1933.
A mimeographed summary of this report has been issued as Station Note
No. 8.

To supply these data, during the summer of 1934 a series of tests was made on both cherty and sandy soils of the Sylamore Experimental Forest in northern Arkansas and on yellow silt loam soils of the Shawnee Experimental Forest in southern Illinois. Both areas are in the unglaciated region of the Ozark highland which extends from southern Illinois through southern Missouri and northern Arkansas. The Sylamore area is representative of the great Ozark forest region of Missouri and Arkansas, while the Shawnee area is typical of the unglaciated loess-mantled areas of southern Illinois, southern Indiana, and southeastern Ohio.

It proved impracticable to use the brass tubes of the former study for absorption tests in cherty soil; consequently water absorption was determined by pouring four successive one-liter portions of water into a square 12-inch wooden frame sealed with wet clay to the mineral soil from which the leaf litter had been removed. The inside of the open frame was lined with strips of galvanized sheet iron the width of the frame. The joining edges of the metal were soldered to prevent leakage. This method of procedure proved highly successful and gave striking results of the relative water-absorbing capacities under the conditions of the experiment. One hundred tests were made on each site and the differences in rates of absorption were very significant. The actual absorption rates found by the frame method naturally vary considerably from those secured in the previous work with 2-inch brass tubes, but the relative results under the soil conditions tested are convincingly similar. With very heavy rainfall, where the surface water on bare soil becomes turbid and the soil puddled, the ratio of absorption in undisturbed woods to absorption in burned woods or pasture would no doubt be much higher, especially on steep slopes.

The comparative volume weights of a 6-inch soil column $2\frac{1}{2}$ inches in diameter were 523, 654, and 667 grams, respectively, for undisturbed forest, burned forest, and pasture soils of the southern Illinois yellow silt loam. Stated in percentages, the upper six inches of the pasture soil was about 28 per cent heavier, and the burned forest soil was 25 per cent heavier, than the same volume of soil from the undisturbed forest. Those differences represent increases in compactness and corresponding losses in porosity when the forest is cleared and pastured or when the woods are repeatedly and severely burned. It was obviously impossible to secure comparable weights of the Arkansas cherty silt loam, because of its stony structure.

The following table gives the number of cubic centimeters of water absorbed per second, for each of the four successive liters applied, under the various conditions of soil tested in this experiment.

RATE OF WATER ABSORPTION IN CUBIC CENTIMETERS PER SECOND PER SQUARE FOOT OF SOIL (a)

<u>SOIL TYPE</u>	<u>SITE CONDITIONS</u>	<u>FIRST LITER</u>	<u>SECOND LITER</u>	<u>THIRD LITER</u>	<u>FOURTH LITER</u>
Yellow silt loam Illinois	Undisturbed oak woods	21.83	23.36	22.78	21.23
	Burned oak woods	7.60	4.63	3.40	2.64
	Open pasture	2.52	1.34	1.01	.86
Cherty silt loam Arkansas	Undisturbed oak woods	55.87(c)	44.87(c)	38.76	32.05
	Burned oak woods	14.25	9.78	6.12(b)	5.10(b)
	Open pasture	17.73(c)	10.47(c)	6.16	4.74
Sandy soil Arkansas	Old-field pine woods	53.19	35.21	21.10(b)	14.71(b)
	Open pasture	12.32	7.66	8.04(b)	6.37(b)
	Undisturbed oak woods	64.10	46.08	40.00	30.50
	Open pasture	24.33	16.84	14.35	12.92

(a) Each figure represents the average of 100 tests unless otherwise indicated.

All items over three times Standard Deviation are eliminated.

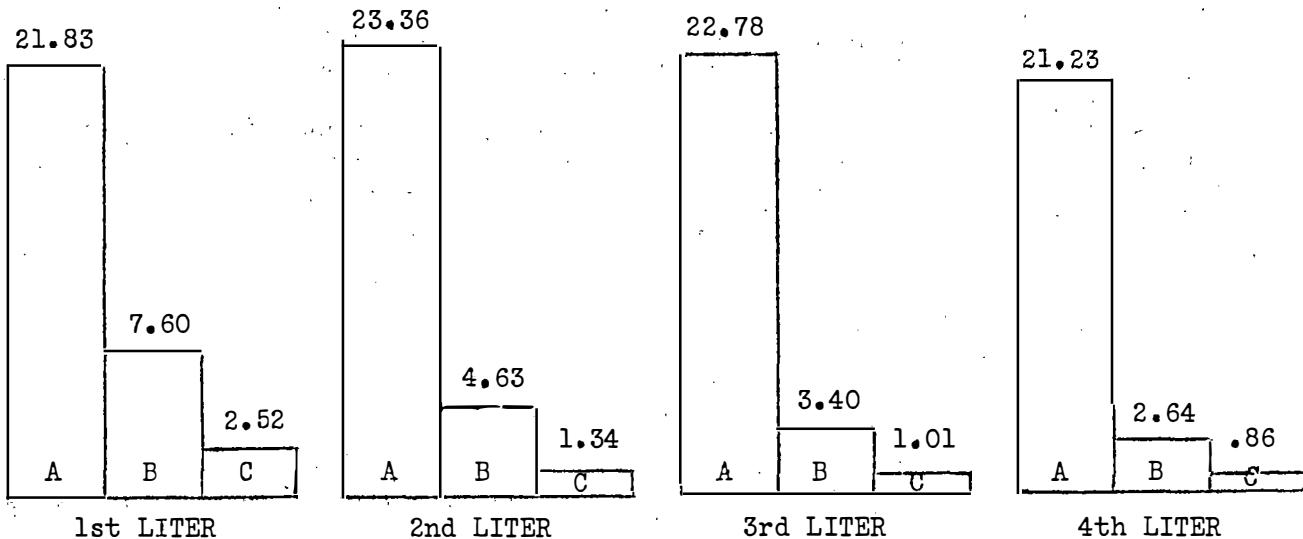
(b) Less than 100 tests. (c) 200 tests.

The block diagrams below, based upon the figures of the table, show very clearly that in the case of the Illinois silt loam soils there is a very great decrease in the water absorptive capacities of severely burned forest and pastured soils compared with the undisturbed woods. In the case of the latter, the rate of absorption, for each successive liter of water applied, remained relatively constant throughout the test, whereas in the case of the burned woods and pastured soils, the rate of absorption diminished with each application of water. For both the burned woods and pastured soils the rate of absorption of the fourth liter was only 35 per cent that of the first.

AVERAGE VOLUMES OF WATER IN CUBIC CENTIMETERS PER SECOND PER SQUARE FOOT ABSORBED WHEN APPLIED IN FOUR SUCCESSIVE ONE-LITER PORTIONS

A = Undisturbed Woods B = Burned Woods C = Open Pasture

Yellow Silt Loam - Southern Illinois



This decrease in water absorption can be explained by the compaction of bare surface soil which occurs during rainfall, and by the sealing of the soil pores as the finer particles are washed downward. The porosity of the forest soil, which is preserved by the protective covering of leaf litter, is lost when the litter is destroyed by fire or by the grazing of livestock. Trampling further compacts the pasture soils.

Furthermore, an exposed, dry, structureless soil is very difficult to wet; dry soil particles act very much as if they were oiled, and capillarity does not become active until water makes actual contact with the soil particles. This contact is made much more slowly with dry soil than with the slightly moist soil found under leaf litter. This slowness to absorb water is a very important factor following a drought. On steep slopes the run-off of rainfall may be considerable before the dry, compacted soils are able to function even with their reduced water absorptive capacities.

The cherty Ozark soil was found to absorb water more rapidly than did the Illinois silt loam, as might be expected from its stony structure, yet the soils of the repeatedly burned woods and the pastures lost their porosity to a remarkable degree. The diagrams on page 5 show that the rate of absorption of the undisturbed forest soils decreased somewhat with each successive application of water, but not nearly as rapidly as it did in the soils of the burned woods and the pastures. When the fourth liter of water was applied, the rate of absorption in the undisturbed woods was 68 per cent of the first application, whereas, in the case of the burned woods and pasture, it had dropped to 36 per cent and 27 per cent, respectively.

By consulting the table, it may be seen that although the undisturbed woods on sand and on cherty silt loam have similar rates of absorption, the rate for the pasture on sand is greater than that for pasture on the cherty silt loam. The rate for the fourth application of water on the sand pasture is 2.72 times as great as that on cherty silt loam pasture. This indicates that sandy soil loses less porosity relatively than does a silt loam. It must not be overlooked, however, that the absorption rate for woods on sand decreased about $\frac{2}{3}$ when the land was cleared and pastured. It is evident that even on sand there is a significant loss of water absorption brought about by exposure and pasturing.

The tests on the old-field pine site show that porosity is regained when a cleared area is reforested with pine. In this particular case, the results were less striking, no doubt, because of the fact that the pine area had been repeatedly burned up until about six years ago. The pine stand was about 48 years old.

The results of this series of water absorption tests, together with those of the original study which it supplements, offer convincing data on the effectiveness with which forest cover influences water absorption and retards run-off. On silt loam and clay soils of fine texture this influence is very great, and even on stony and sandy soils it is most significant. Under conditions of heavy rainfall on steep slopes, the actual run-off

is undoubtedly much greater on unprotected soils than the data of this experiment indicate. The results also emphasize the need for forest protection against fires and excessive pasturing of livestock, and for reforestation of cleared, non-agricultural lands, as important measures of run-off control. The cost of engineering works for erosion control, flood control, and water conservation may be reduced greatly, and their efficiency increased, by forest conservation and restoration.

AVERAGE VOLUMES OF WATER IN CUBIC CENTIMETERS PER SECOND PER SQUARE FOOT
ABSORBED WHEN APPLIED IN FOUR SUCCESSIVE ONE-LITER PORTIONS

A = Undisturbed Woods B = Burned Woods C = Open Pasture

Cherty Silt Loam - Northern Arkansas

55.87

